changes in India are associated very big changes in the strength of the upper currents; and it is an obvious

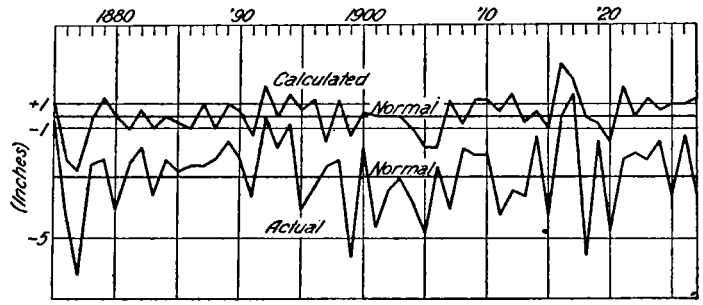


FIG. 4.—Forecast on June 1 of Indian monsoon, June-September. (1908 Formula, R=0.58)

hypothesis that when the change in the upper currents takes place with unusual vigor the seasonal rainfall will be abundant. The pilot-balloon observations hitherto made strongly support this hypothesis, and what appears to hold in India very probably holds over a far wider region. Moreover, the idea that upper-air conditions are vital to the study of world weather derives support from the table of relationships with the Nile. The significant relationships with other stations for its single season number 31, while the greatest number for a single season at any other center is 24; and as the corresponding number for pressure at Cairo is only 8, it seems likely that this effect of the Abyssinian rainfall is brought about by the agency of the upper air, not by surface conditions. Similarly, the monsoon rainfall of India has eight significant relationships elsewhere, but June to August pressure in northwest India only once.

It is to be hoped, therefore, that the tables of the *Réseau Mondial*, to which statistical workers have been enormously indebted in the past, will in future contain monthly means of air motion at fixed heights above such observatories as can provide the data.

RAINFALL MAPS OF CUBA

By EDWIN J. FOSCUE

[Southern Methodist University, Dallas, Tex., May 24, 1928]

Cuba has an area of more than 44,000 square miles and is approximately the size of Pennsylvania. In spite of the relatively slight relief there are pronounced differences in the total rainfall of the various parts of the island, feels that a graphic presentation of the available data should be of interest to students of tropical geography. Most of the data for these maps were obtained from the excellent publication by Dr. Oliver L. Fassig, on "Rain-

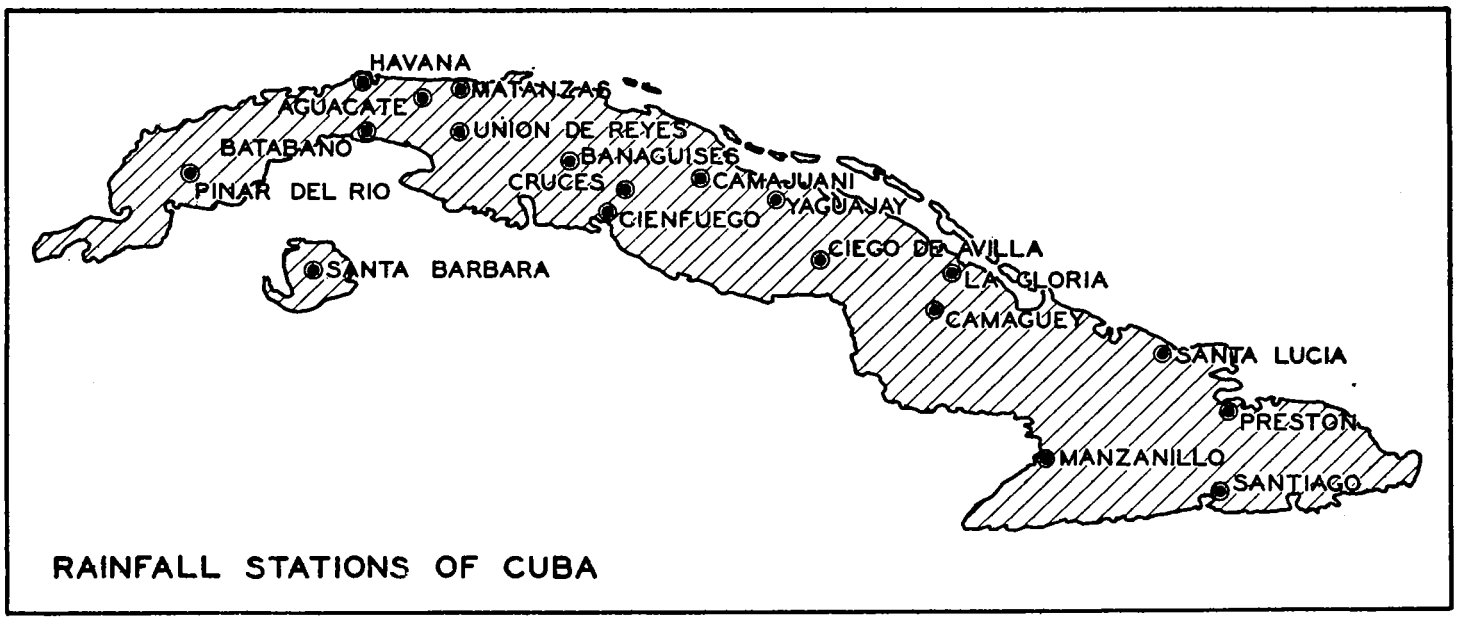


FIG. 1

due largely to its embayed coast and to the seasonal shift of prevailing winds.

Accurate and detailed records of the rainfall on the island are few, and for the surface involved, the 19 long-record stations used in the series of maps presented with this paper are by no means sufficient to make a detailed study of the rainfall of the island. However, as there exist no detailed maps of Cuba showing the annual and monthly distribution of precipitation,[1] the author fall and Temperature of Cuba."[2] Rainfall data in this bulletin are given for 19 stations on the island with records varying between 14 and 25 years, with an average of about 20 years. Since the rainfall in the Tropics is so variable from year to year, it seemed desirable to get as long a record as possible for each station, so as to increase the accuracy of the maps. For uniformity the short-record stations were adjusted on the long-record stations so that the resultant was a 25-year average for each of the 19 stations shown on the identification map

[1] The most complete general maps on rainfall and cloudiness in the West Indies are to be found in "Bewolkungs-, Niederschlags- und Gewitterverhältnisse der westindischen Gewässer un der angrenzenden Landmassen," by Dr. W. Kloster. (Aus dem Archiv der Deutschen Seewarte, Vol. 40, No. 1, pp. 3-67.)

[2] Fassig, Oliver L: Rainfall and Temperature of Cuba, Bull. No. 1, of the Tropical Plant Research Foundation.

(fig. 1). The formula used in computing this adjusted average is given below.[3]

After the adjusted figures of monthly and annual rainfall, as shown in the accompanying table, were calculated for the 19 stations, a series of monthly rainfall charts were made to show the rainfall types on the island. The more significant rainfall types are shown in the charts for Habana, Union de Reyes, Preston, and Santa Barbara. Habana has the lowest record of any station on the island, with a total only 43 inches, while the near-by station of Union de Reyes has the highest, with more than 72 inches. Preston, in northeastern Cuba, has a pronounced winter maximum, while Santa Barbara, on the Isle of Pines, has a double summer maximum. (Fig. 2.)

On the map of annual rainfall, isohyets of 5 inches were used, with a shading for every 10 inches. This map (Fig. 3) shows in a general way the concentration of rain in the southwestern part of the island, and the relatively light rainfall throughout the entire eastern half of the island. The eastern and western halves of the island are not exactly comparable, however, as all of the stations in the eastern part are at, or near, sea level, and do not tell the conditions in the mountains back of Santiago, which rise in places above 5,000 feet.[4] The map shows, however, that the region of the summer maxima has by far the greatest accumulated rainfall for the year.

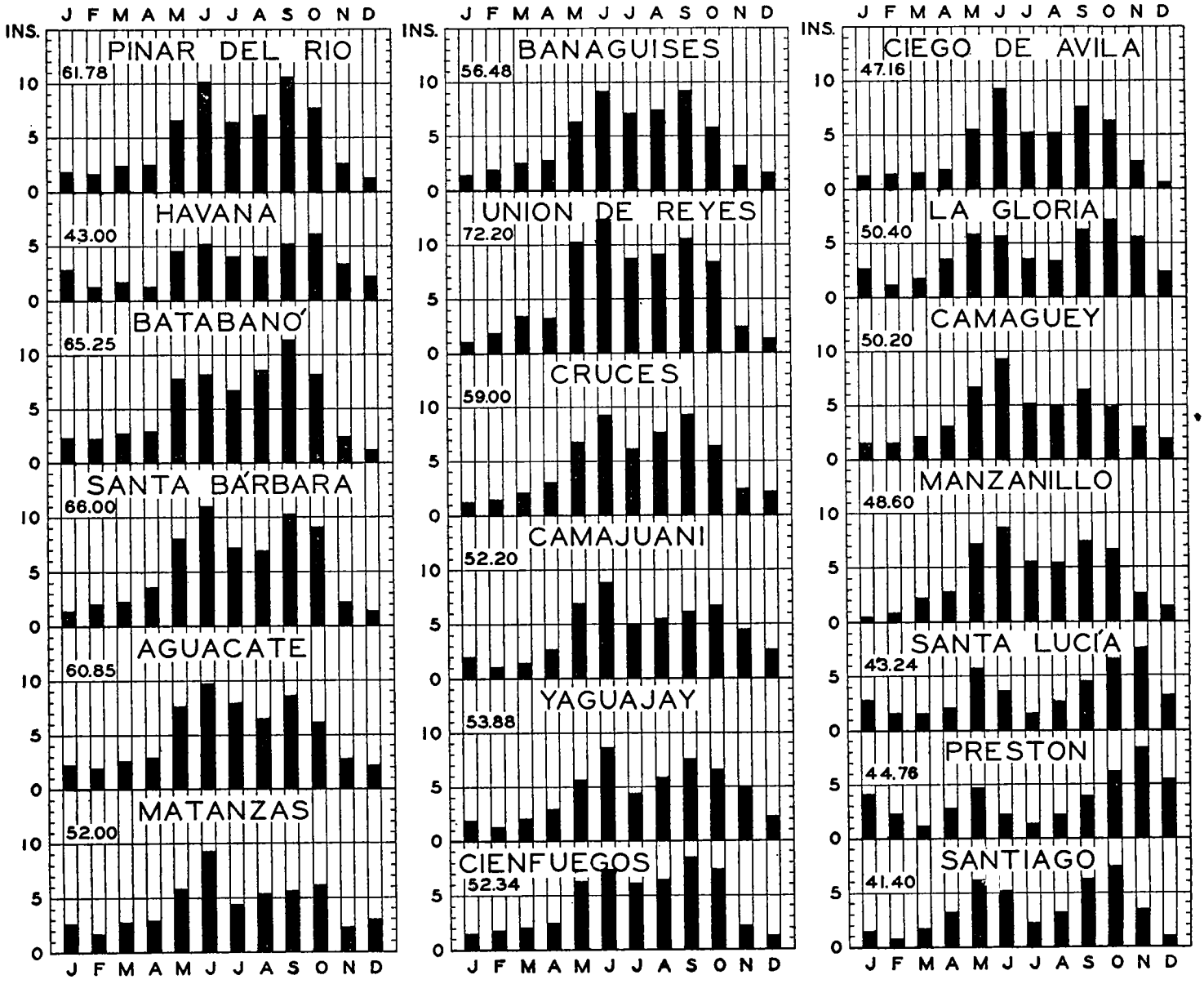


FIG. 2

MONTHLY RAINFALL

The maps showing the monthly distribution of rainfall for the island of Cuba (fig. 4) were constructed from the adjusted monthly means shown in Table 1. The same difficulty was experienced here as with the annual map. Due to a lack of stations in the mountainous southeastern part of the island, it was quite difficult to make a fair

[3] Formula:

$$\frac{\text{Total rainfall for short record station}}{\text{Total rainfall for long record station (same years as short record station)}} \times \text{Total rainfall for long record station (25 years)} = x$$

x = adjusted total for short record station for 25 years.

$\frac{x}{25}$ = adjusted annual rainfall for the short stations.

The monthly means were computed proportionately from the annual mean.

[4] See Reed, W. W.: "Climatological Data for the West Indian Islands," in MONTHLY WEATHER REVIEW, April, 1926, 54: 140-141.

representation of the probable rainfall in that section, and in consequence the writer had to be satisfied with mere suggestions now and then, similar to that on the annual map. The maps show isohyetal lines for every inch of rainfall, and different shades for each 2 inches. In addition to this the prevailing wind directions are placed in each monthly map to show the influence of these winds upon the distribution of precipitation.[5]

The months of January, February, March, and April, and of November and December, have the lightest rainfall, while the hot months of June, July, August, and September have the greatest rainfall. Two pronounced maxima occur over most of the island in June and September, the rainfall during July and August being lighter than either of these. May and October represent transitional months between the heavy rainfall of summer and the lighter rainfall of April and November. The June maximum over most of the island is due to the numerous convectional showers brought about by the vertical rays of the sun passing over Cuba twice during that month, and to the heavy rainfall along the south coast of the western part of the island facing the prevailing on-shore winds from the southeast. The September maximum is largely the result of tropical hurricanes that are most numerous in the West Indies during that month. The path of greatest frequency of these cyclonic storms lies through the western part of the island.

Considering the areal distribution of precipitation on the monthly maps, it appears that the prevailing winds have a marked influence. During the winter months the northeast trade-winds prevail and the eastern half of the north coast is exposed. This brings the heaviest rainfall in the northeastern part of the island, centering around the town of Preston, with the rain shadow covering most of the remainder of the island. The area included in this winter maximum is small. By the beginning of May the prevailing winds turn through east to southeast, and bring an on-shore wind to the southern side of the island. This gives the stations on the southern and southwestern parts of the island the heaviest rainfall during the summer, and places the northeastern coast in the rain shadow, with the minimum precipitation at Preston, the same place that had the maximum rainfall during the winter. It should be kept in mind, however, that there are no stations in the mountainous southeastern part of the island. That section, with its high mountains, undoubtedly has a much heavier rainfall on its windward slope than can be shown on the maps. In November the winds change back to their former direction, and the northeast trades prevail from then until the end of April.

Since the relief of Cuba is slight, with the exception of the mountains back of Santiago, the seasonal influence of prevailing winds, and the embayed coast, appear to be the most important factors in the areal distribution of rainfall.

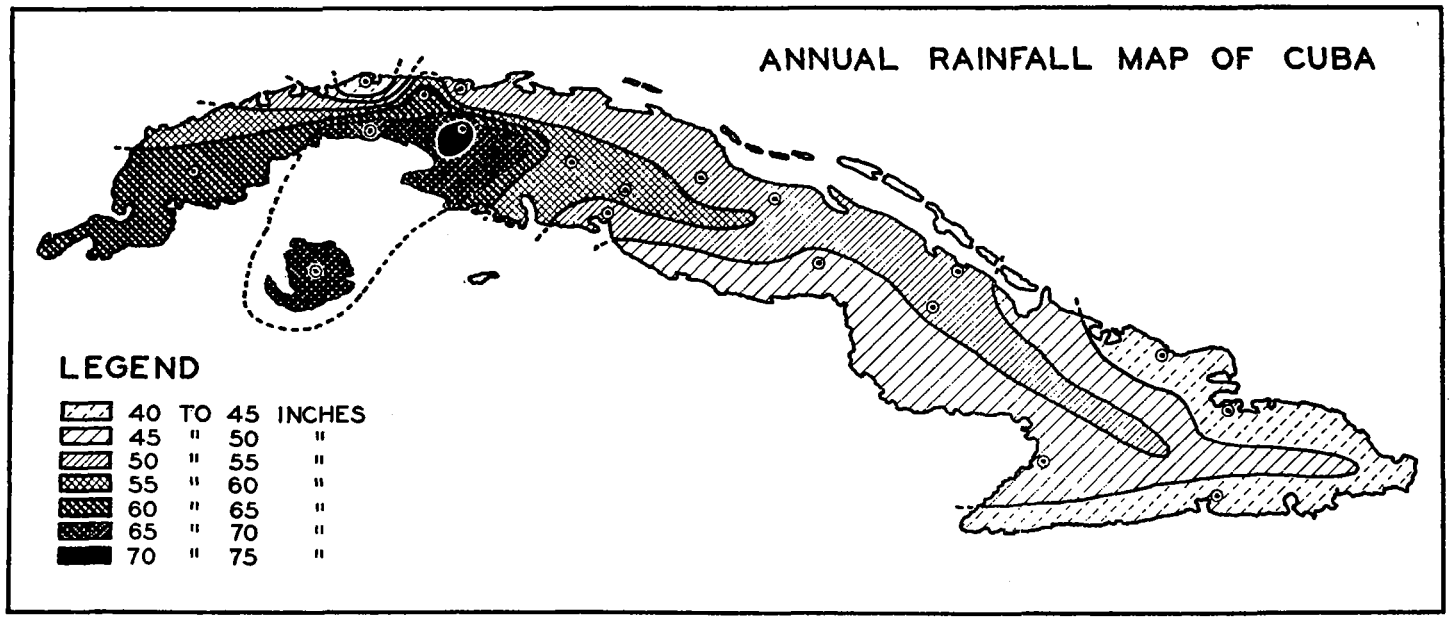


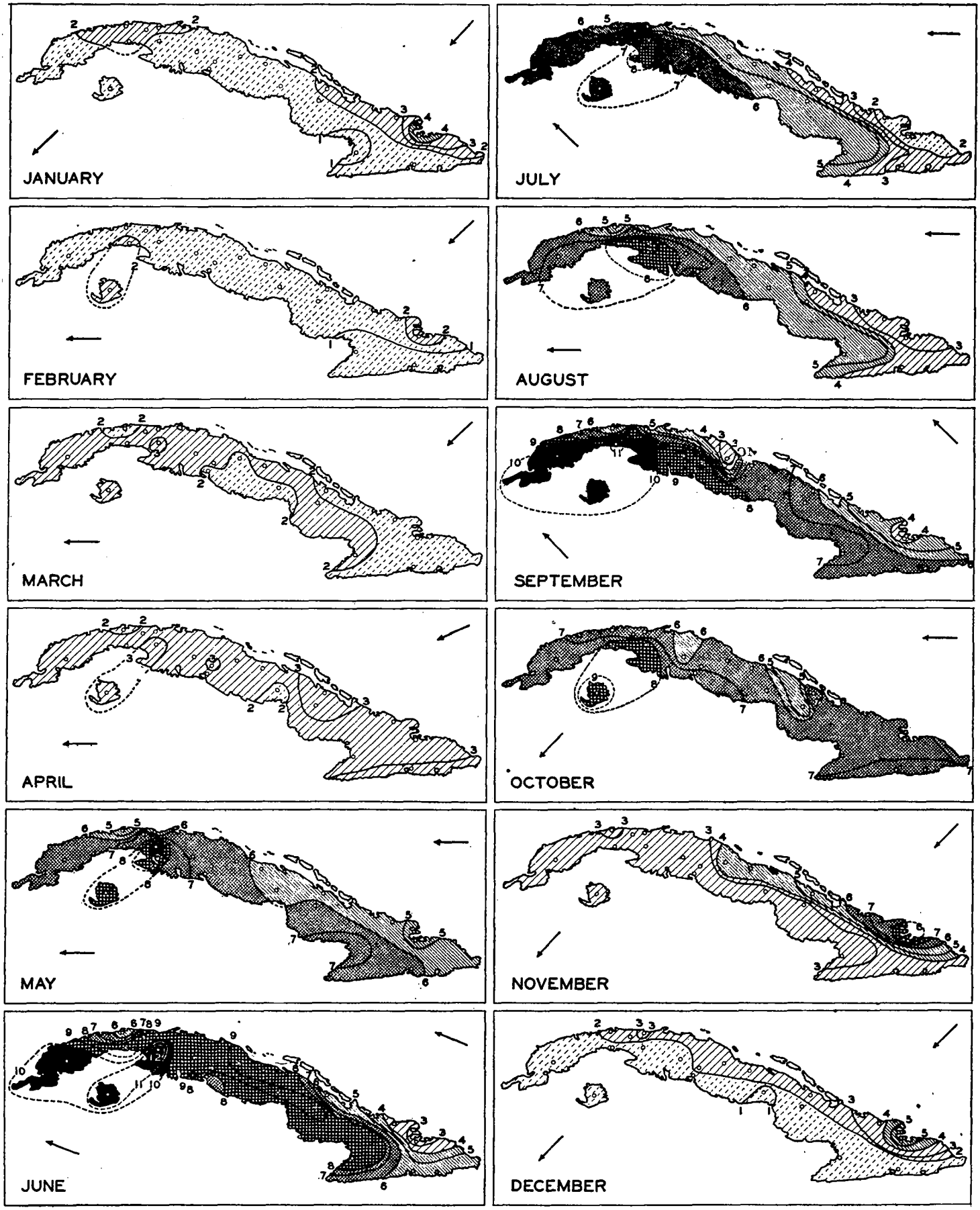
FIG. 3

TABLE 1.—*Adjusted monthly and annual rainfall of Cuba (19 stations)*

No.	Station	Jan.	Feb.	Mar.	Apr.	May	June
1	Pinar del Rio	1.82	1.74	2.48	2.62	6.97	10.29
2	Havana	2.98	1.33	1.78	1.58	4.71	5.26
3	Batabanó	2.42	2.07	2.53	2.69	7.92	8.18
4	Santa Barbara	1.40	2.01	2.24	3.66	8.08	11.05
5	Aguacate	2.18	1.85	2.46	2.63	7.75	9.88
6	Matanzas	2.52	1.36	2.32	2.37	5.94	9.32
7	Banaguises	1.17	1.79	2.48	2.84	6.45	9.36
8	Union de Reyes	0.99	1.88	3.15	3.02	10.20	12.27
9	Cruces	1.40	1.68	2.16	3.16	6.90	9.30
10	Camajuani	1.93	1.05	1.44	2.73	6.02	8.80
11	Yaguajay	1.95	1.40	2.08	2.93	5.70	8.40
12	Cienfuegos	1.26	1.44	1.87	2.29	6.44	7.63
13	Ciego	1.03	1.19	1.26	1.96	5.44	9.41
14	La Gloria	2.61	1.29	1.62	3.50	5.68	5.62
15	Camaguey	1.49	1.36	2.20	3.28	6.90	9.40
16	Manzanillo	0.57	0.80	2.05	2.84	7.14	8.70
17	Santa Lucia	2.85	1.40	1.38	2.00	5.80	3.58
18	Preston	4.03	2.21	1.25	2.88	4.65	2.36
19	Santiago	1.44	0.83	1.67	3.15	6.15	5.12

No.	Station	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1	Pinar del Rio	6.61	7.01	10.65	7.74	2.46	1.39	61.78
2	Havana	4.33	4.27	5.18	6.21	3.20	2.17	43.00
3	Batabonó	6.41	8.95	11.77	8.46	2.62	1.28	65.25
4	Santa Barbara	7.20	7.15	10.40	9.25	2.14	1.55	66.00
5	Aguacate	7.88	6.37	8.84	6.05	2.84	2.12	60.85
6	Matanzas	4.50	5.40	5.75	6.10	2.61	3.32	52.00
7	Banaguises	7.02	7.30	9.02	5.32	2.28	1.58	56.48
8	Union de Reyes	8.55	9.05	10.55	8.38	2.24	1.43	72.20
9	Cruces	6.20	7.90	9.44	6.40	2.42	2.15	59.00
10	Camajuani	4.95	5.20	2.05	6.75	4.61	2.68	52.20
11	Yaguajay	4.36	5.78	7.55	6.50	4.99	2.08	53.88
12	Cienfuegos	6.18	6.48	8.04	7.32	2.14	1.25	52.34
13	Ciego	5.28	5.21	7.87	6.70	2.58	0.56	47.16
14	La Gloria	3.60	3.40	6.18	7.08	5.57	2.30	50.40
15	Camaguey	5.02	5.00	6.52	4.90	2.82	1.86	50.20
16	Manzanillo	5.40	5.52	7.72	6.50	2.43	1.24	48.60
17	Santa Lucia	1.71	2.62	4.28	6.50	7.60	3.05	43.24
18	Preston	1.50	2.08	3.88	6.42	8.21	5.31	44.76
19	Santiago	2.14	3.41	6.25	7.05	3.44	1.00	41.40

[5] From Monthly *Sailing Charts* of the North Atlantic Ocean. United States Coast and Geodetic Survey, Department of Commerce, Washington, 1923.



MONTHLY RAINFALL OF CUBA

FIG. 4